Digital Elevation Model of San Juan, Puerto Rico: Procedures, Data Sources, and Analysis

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Summary

In October of 2015, NOAA's National Centers for Environmental Information (NCEI) developed a topographic-bathymetric digital elevation model (DEM) of San Juan, Puerto Rico (Figure 1) for the National Tsunami Hazards Mitigation Project (NTHMP). The 1/9 arc-second DEM will be used to support improving the coastal tsunami inundation forecasts, storm surge modeling, community preparedness and hazard mitigation. This DEM covers the coastal area of San Juan, Puerto Rico. The extents of this DEM, procedures, data sources, and analysis are described below.

**Figure 1. San Juan, Puerto Rico (PRVD) DEM**
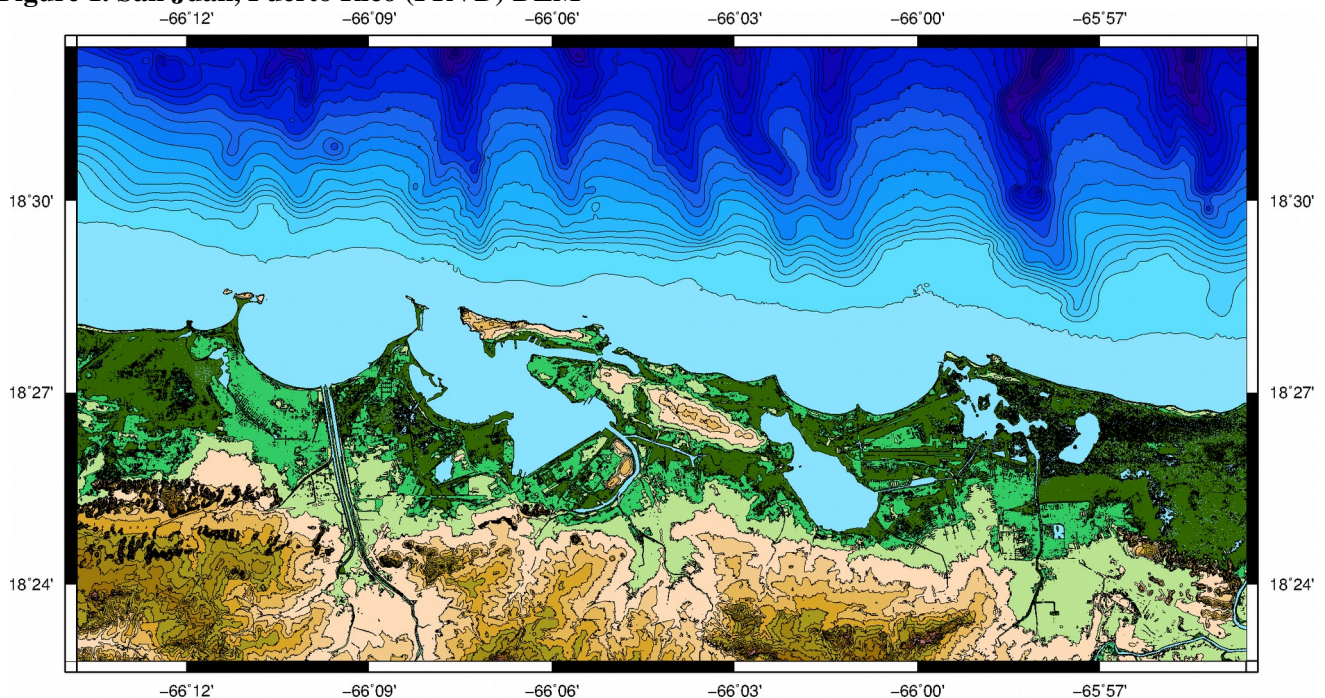
DEM Specifications

The San Juan DEM was built to the specifications listed in Table 1. Figure 2 shows the 1/9 arc-second boundary in red.

Table 1. Specifications for the Pensacola, Florida DEM.

Grid Area	San Juan, Puerto Rico
Coverage Area	-66.23° to -65.91° W, 18.38° to 18.54° N
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	Puerto Rico Vertical Datum (PRVD)
Vertical Units	Meters
Cell Size	1/9 arc-seconds
Grid Format	ASCII raster grid

Figure 2. Map image of the DEM boundary for the San Juan, Puerto Rico DEM in red.
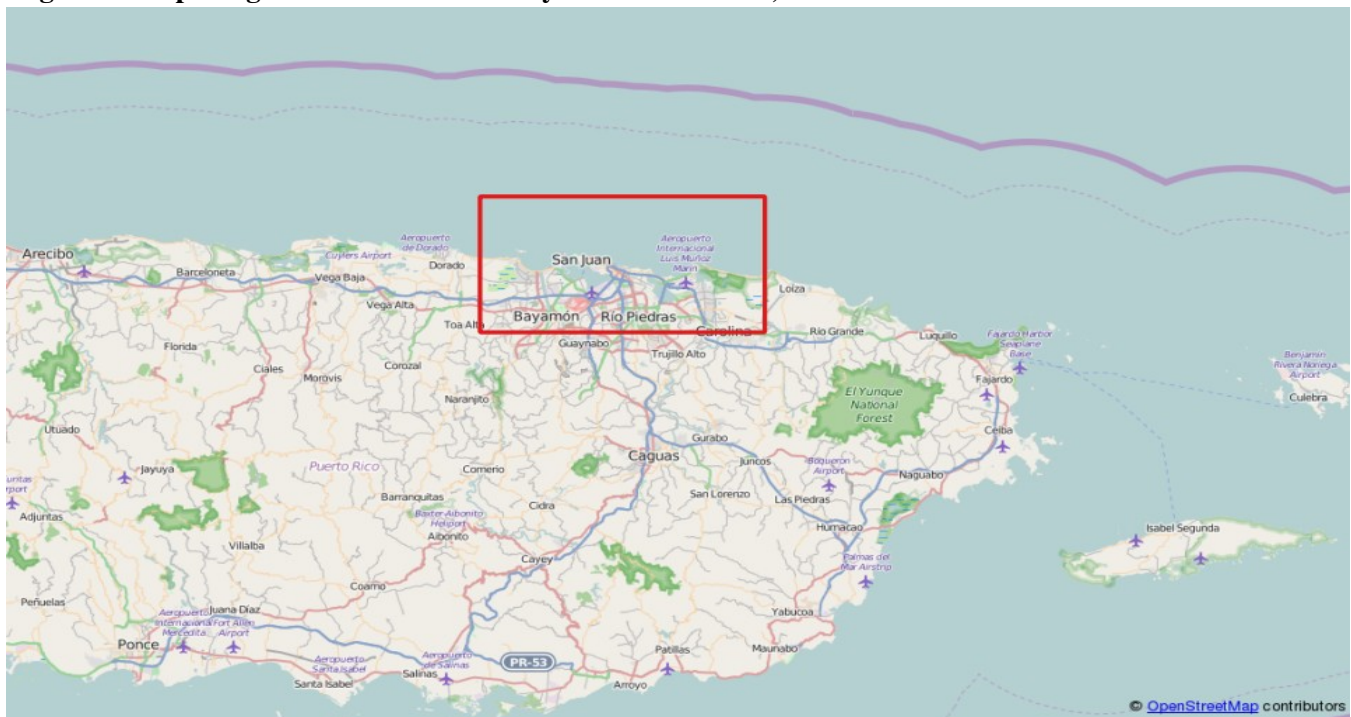
Data Sources and Processing

The digital coastline used in developing the San Juan DEM was generated by editing the Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG) shoreline based on the Google satellite imagery layer. The digital coastline was converted into a polygon for use in masking topography and eliminating interpolated data.

Bathymetry data used in the compilation of the San Juan DEM included sounding data from NOAA agencies, bathymetric lidar data and completed datasets from NCEI (Table 2).

Topographic data used in the compilation of the San Juan DEM included lidar data from various sources including USACE and USGS.

The bathymetric data were transformed from their original datums to a horizontal datum of WGS 84 and a vertical datum of PRVD prior to DEM development using a vertical transformation parameters within NOAA's Vdatum tool. All topographic data originated in WGS 84 and PRVD prior to development, so no added transformations were needed.

Table 2: Bathymetric and Topographic Data Sources used in compiling the Pensacola DEM.

Source/Title	Date	Data Type	Spatial Resolution	Horizontal Datum	Vertical Datum
USACE Puerto Rico Lidar	2004	Topographic Lidar	< 1 meter	WGS84 Geographic	PRVD
Puerto Rico Lidar: Greater San Juan, Puerto Nuevo, Rio De La Plata	2013	Topographic Lidar	< 1 meter	WGS84 Geographic	PRVD
USACE SHOALS	2001	Bathymetric Lidar	~ 1 meter	WGS84 Geographic	PRVD
USACE	2012 - 2014	Bathymetric Survey Soundings	1 – 10 meter	WGS84 Geographic	Mean Lower Low Water (MLLW)
University of Puerto Rico	1995 - 2011	Bathymetric Survey Soundings	Varied	Varied	Varied
NOAA Multibeam	N/A	Multibeam Hydrographic	Varied	WGS84 Geographic	Mean Sea Level (MSL)
NOAA NOS	1887 - 2013	Hydrographic Survey Soundings	1 meter to several kilometers	NAD 1983 Geographic	Mean Lower Low Water (MLLW)

DEM Development

After the data were transformed to common horizontal datums, the data were visually reviewed for consistency and errors. Where more recent, higher resolution data existed, older data were superseded. In some areas, older multibeam data were retained as newer overlapping data contained errors during data acquisition. The edited and evaluated data were then converted to ASCII xyz format using GDAL then gridded at 1/9 arc-second using GMT's' surface' tool to generate a bathymetric surface which provided full data coverage of the DEM area. The surface was then clipped using the digital coastline to create the final bathymetric DEM. The final bathymetric DEM was then converted to ASCII xyz for use as input in generating the final DEM.

The MBSystem program 'mbgrid' was used to generate the final 1/9 Arc-Second San Juan, Puerto Rico DEM using a weighted tight spline algorithm Highest weights were given to topographic and bathymetric lidar data and lowest weights were given to NOS hydrographic soundings.

Recommendations

Recommendations to improve the San Juan, Puerto Rico 1/9 arc-second DEM are listed below:
- Conduct topographic/bathymetric lidar surveys of coastal areas along lagoons and harbors.
- Conduct high resolution bathymetric surveys of deep water areas off the coast of San Juan.

Acknowledgments

References

Taylor, L.A., Eakins, B.W., Carignan, K.S., Warnken, R.R., Sazonova, T., Schoolcraft, 2008. Digital Elevation Models of Puerto Rico: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-13, National Geophysical Data Center, Boulder, CO, 27 pp.

Wessel, P., and W. H. F. Smith, A Global Self-consistent, Hierarchical, High-resolution Shoreline Database, J. Geophys. Res., 101, #B4, pp. 8741-8743, 1996.